Report for 2005PA40B: Nitrate Source Tracking: Combining Isotopic, Microbial, and Chemical Tracers in a Mixed Land-Use Watershed

Publications

- Other Publications:
    - Buda, A.R. and D.R. DeWalle. 2005. Tracing Nitrate Sources in a Mixed Land-Use Watershed During Baseflow and Peakflow Conditions. Eos Transactions AGU. 86(52). Fall Meeting Supplement. Abstract H21F-06. Oral Presentation

Report Follows

PRINCIPAL FINDINGS AND SIGNIFICANCE

Six storm events were sampled during 2005 in Spring Creek, a predominately karst geology watershed in central Pennsylvania. For each storm event, five nested subwatersheds representing a downstream progression of forested, agricultural, urban, and mixed land-uses in Spring Creek were sampled for chemical, isotopic (^{15}N and ^{18}O in nitrate), and microbial (*E. coli*) tracers to assess potential sources of nitrate during baseflow and peakflow conditions. The distribution of storms throughout the year also allowed for comparisons of tracers and nitrate sources during the growing and dormant seasons. Preliminary results and conclusions from this sampling effort are presented below.

- During baseflow conditions, ^{15}N in nitrate was a better discriminator of nitrate sources than ^{18}O in nitrate. In general, ^{15}N in nitrate was lowest for Galbraith Gap Run, a predominately forested watershed underlain by sandstone. The low ^{15}N values for Galbraith Gap Run showed that nitrate derived from microbial nitrification in soils was the most likely source of nitrate during baseflow conditions. In comparison to the forested watershed, ^{15}N in nitrate was slightly greater in baseflow for Cedar Run (agricultural), Thompson Run (urban), and Spring Creek Houserville (mixed land-use site upstream of UAJA sewage treatment plant), all of which are underlain by karst geology and had fairly similar ^{15}N signatures. This suggested a mixture of soil-derived nitrate and manure or sewage nitrate sources for these sites during baseflow. Moreover, samples taken from Thompson Spring and Bathgate Spring, two local karst springs, had similar values of ^{15}N in nitrate to Cedar Run, Thompson Run, and Spring Creek at Houserville, which implied that nitrate in these streams may be primarily derived from the same groundwater sources. Spring Creek at Rock Road (mixed land-use) had the highest baseflow ^{15}N in nitrate of all sites, which was primarily due to high ^{15}N inputs of sewage nitrate from the UAJA treatment plant about 2.2 kilometers upstream. A significant positive relationship between ^{15}N and chloride also verified the importance of sewage nitrate at this site.

- ^{15}N and ^{18}O in nitrate were useful for showing the importance of overland flow delivery of nitrate, especially in the Thompson Run watershed (urban). At baseflow, ^{15}N and ^{18}O in nitrate showed that nitrate sources were primarily derived from organic sources (manure / sewage). During a storm event, ^{15}N and ^{18}O shifted toward precipitation nitrate signatures, which demonstrated that nitrate from urban stormwater runoff predominated during the storm. As a result, ^{15}N and ^{18}O in nitrate appear to be excellent tracers of urban stormwater and would be very useful for evaluating the effectiveness of urban best management practices (BMPs) for stormwater mitigation.

- ^{15}N and ^{18}O in nitrate were also useful to illustrate the differences in behavior during storms for rural watersheds in karst versus sandstone geology. In general, ^{15}N and ^{18}O in nitrate showed little changes from baseflow to peakflow for rural karst subwatersheds (Cedar Run and Spring Creek at Houserville), suggesting that sources of nitrate may be predominately from the same groundwater throughout storm events in these basins. On the other hand, nitrate stable isotopes in Galbraith Gap Run, a forested watershed with sandstone geology and shallow soils, shifted more toward precipitation nitrate signatures during storms. This implied that shallow subsurface soil flow paths in the sandstone watershed delivered more precipitation nitrate than in watersheds with karst geology and deeper soils.

- ^{15}N in nitrate varied seasonally during baseflow conditions for all sites, although the variations were not substantial. In general, ^{15}N showed slight declines from spring through fall for Cedar Run, Thompson Run, and Spring Creek at Houserville. Galbraith Gap Run showed a slight increase in ^{15}N, although it was minor. Spring Creek Rock Road and the sewage effluent from UAJA showed more substantial and well correlated increases in ^{15}N during 2005, which suggested that these sites may need to be sampled at different times of the year to adequately characterize sources of nitrate. ^{18}O in nitrate increased slightly during 2005 at all sites, but the increases were minimal. In general it appears, except for UAJA sewage effluent, that temporal variability of nitrate stable isotopes is minimal throughout the year and that potential nitrate sources can be assessed with relatively few samples at a given site. Sampling efforts should focus more on spatial variability of nitrate stable isotopes that exist between watersheds with different land-uses and geology.

- Nitrate stable isotopes (^{15}N and ^{18}O) in precipitation varied seasonally and within individual storm events. These variations may provide information on pollutant sources and atmospheric processes that are affecting precipitation nitrate for this site in central Pennsylvania.

- Denitrification was not considered a major control on stream nitrate isotopes during this study. Nitrate stable isotope results from a downstream (Lagrangian) sampling program for four distinct reaches (3 – 5 km long) in the mainstem of Spring Creek during a typical summer low-flow period (June 2005) suggested that decreases in nitrate loads were not primarily due to denitrification. Ultimately, we can conclude that nitrate stable isotopes are likely to be conservative during in-stream transport and should represent nitrate sources and not in-channel transformation processes during warm season baseflow periods.

- The overall objective of the project is to combine information from chemical, isotopic, and microbial tracers to identify important sources of nitrate in streams within the Spring Creek watershed. We are in the process of evaluating the potential sources of *E. coli* bacteria in streams using Eubacterial Repetitive Intergenic Consensus (ERIC) polymerase chain reaction (PCR). Once this analysis is complete, all tracer information will be analyzed using multivariate statistics (e.g. classification and regression trees, discriminant analysis) to help develop models to identify nitrate sources for all stream sites during baseflow and peakflow conditions.

STUDENTS SUPPORTED

Anthony Buda, Forest Resources, Ph.D.

PRESENTATIONS AND OTHER INFORMATION TRANSFER ACTIVITIES

Buda, A.R. and D.R. DeWalle. 2006. Tracing Nitrate Sources in a Mixed Land-Use Watershed During Baseflow and Peakflow Conditions. Environmental Chemistry Student Symposium – Center for Environmental Chemistry and Geochemistry (CECG). Penn State University.

First Place Oral Presentation: http://www.essc.psu.edu/CECG_symposium/

Buda, A.R. and D.R. DeWalle. 2005. Tracing Nitrate Sources in a Mixed Land-Use Watershed During Baseflow and Peakflow Conditions. Eos Transactions AGU. 86(52). Fall Meeting Supplement. Abstract H21F-06. Oral Presentation

AWARDS

First Place Oral Presentation, Environmental Chemistry Symposium, Penn State University, 2006